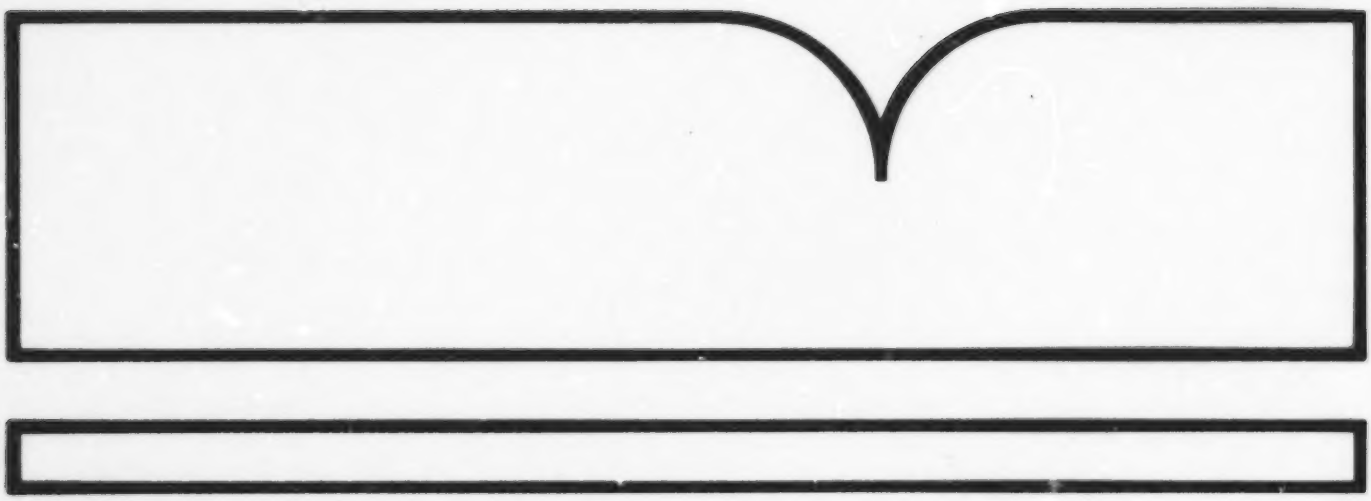
PB86-129319

Hazard Evaluation Division, Standard Evaluation Procedure: Acute Toxicity Test for Estuarine and Marine Organisms (Shrimp 96-Hour Acute Toxicity Test)

(U.S.) Environmental Protection Agency
Washington, DC

Jun 85



U.S. Department of Commerce
National Technical Information Service
NTIS

PB86-129319

EPA-540/9-85-010
June 1985

HAZARD EVALUATION DIVISION

STANDARD EVALUATION PROCEDURE

ACUTE TOXICITY TEST FOR ESTUARINE AND MARINE ORGANISMS

(Shrimp 96-Hour Acute Toxicity Test)

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REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No. PB86 129319/AS

4. Title and Subtitle
HAZARD EVALUATION DIVISION, STANDARD EVALUATION PROCEDURE
Acute Toxicity Test for Estuarine and Marine Organisms (Shrimp 96-Hour Acute Toxicity Test)

5. Report Date
June 1985

6.

7. Author(s)
Daniel Reider

8. Performing Organization Rept. No.
EPA-540/9-85-010

9. Performing Organization Name and Address
U.S. Environmental Protection Agency/OPP/HED/(TS-769C)
401 M Street SW
Washington, D.C. 20460

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Same as #9.

13. Type of Report & Period Covered

14.

15. Supplementary Notes
Supplement to Pesticide Assessment Guidelines Subdivision E - Hazard Evaluation: Wildlife and Aquatic Organisms (EPA-540/9-82-024 and NTIS Order Number PB83-153908), October, 1982.

16. Abstract (Limit: 200 words)
The Standard Evaluation Procedure (SEP) for the Shrimp 96-Hour Acute Toxicity Test is a guidance document primarily intended for Agency reviewers and the regulated industry who evaluate ecological effects data specified in 40 CFR Part 158.145. The SEP is also intended to provide information to the general public indicating how the Agency evaluates these types of studies. As such, it is designed to supplement Subdivision E of the Pesticide Assessment Guidelines: Hazard Evaluation - Wildlife and Aquatic Organisms. This SEP provides an Introduction, Materials and Methods, Reporting Requirements, Reviewer Evaluation, and Appendix of appropriate methods to guide the review and scientific evaluation of pesticide effects on estuarine/marine shrimp.

The SEP for the Shrimp 96-Hour Toxicity Test is only one of a number of SEP's published by the National Technical Information Service as a supplement to Subdivision E of the Pesticide Assessment Guidelines.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unclassified and freely available.	Unclassified.	17
	20. Security Class (This Page) Unclassified.	22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

STANDARD EVALUATION PROCEDURE

PREAMBLE

This Standard Evaluation Procedure (SEP) is one of a set of guidance documents which explain the procedures used to evaluate environmental and human health effects data submitted to the Office of Pesticide Programs. The SEPs are designed to ensure comprehensive and consistent treatment of major scientific topics in these reviews and to provide interpretive policy guidance where appropriate. The Standard Evaluation Procedures will be used in conjunction with the appropriate Pesticide Assessment Guidelines and other Agency Guidelines. While the documents were developed to explain specifically the principles of scientific evaluation within the Office of Pesticide Programs, they may also be used by other offices in the Agency in the evaluation of studies and scientific data. The Standard Evaluation Procedures will also serve as valuable internal reference documents and will inform the public and regulated community of important considerations in the evaluation of test data for determining chemical hazards. I believe the SEPs will improve both the quality of science within EPA and, in conjunction with the Pesticide Assessment Guidelines, will lead to more effective use of both public and private resources.

John W. Melone, Director
Hazard Evaluation Division

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ACUTE TOXICITY TEST FOR ESTUARINE AND MARINE ORGANISMS: SHRIMP 96-HOUR ACUTE TOXICITY TEST

I. INTRODUCTION

A. When Required

Acute toxicity studies with shrimp are required to support registration of an end-use product intended for direct application to the estuarine or marine environment. These studies are also necessary when it is expected that the pesticide would enter this environment in significant concentrations because of its expected use or mobility.

B. Purpose

- To establish acute toxicity concentrations of the active ingredient to nontarget marine and estuarine organisms;
- To compare toxicity information with measured or estimated pesticide residues in the estuarine or marine environment to assess potential impact to invertebrates;
- To provide support for precautionary label statements to minimize adverse effects to estuarine or marine nontarget organisms; and
- To indicate the need for further testing and/or field studies.

C. Test Material

1. Technical Grade

Tests must be conducted with the technical grade of the active ingredient. If more than one active ingredient constitutes a technical product then the technical grade of each active ingredient must be tested separately.

2. End-Use Product

The applicant may be required to test the end-use product as well if:

- The end-use product will be introduced directly into the marine or estuarine environment when used as directed;
- The shrimp LC_{50} of the technical grade of the active ingredient is equal to or less than the expected environmental concentration in the marine or estuarine environment when used as directed;

- An ingredient of the end-use product is expected to enhance the toxicity of the end-use product beyond that expected from the active ingredient(s); or
- The technical product is insoluble in water but the formulated product is soluble in water. In that case the carriers or inerts of the formulated product must be tested in a solvent control.

II. MATERIALS AND METHODS: TESTING STANDARDS/RECOMMENDATIONS

A. Acceptable Protocols

EEB does not endorse any one protocol. It is sometimes necessary and desirable to alter the procedures presented in published protocols to meet the needs of the chemical or test organisms used. However, EEB does recommend some protocols as guidance for developing shrimp acute toxicity tests. These protocols include:

Bahner, L.H., C.D. Craft, and D.R. Nimmo. 1975. A Saltwater Flow-Through Bioassay Method with Controlled Temperature and Salinity. Prog. Fish Cult. 37(3): 126-129.

Committee on Methods for Toxicity Tests with Aquatic Organisms. 1975. Methods for Acute Toxicity Tests with Fish, Macroinvertebrates and Amphibians. U.S. Environmental Protection Agency, Ecol. Res. Series, EPA 660/375-009. 61 pp.

Peltier, William. 1978. Methods for Measuring the Acute Toxicity of Effluents to Aquatic Organisms. U.S. Environmental Protection Agency, Ecol. Res. Series, EPA 600/4-78-012. 52 pp.

Anonymous. 1978. Bioassay Procedures for the Ocean Disposal Permit Program. U.S. Environmental Protection Agency, Office of Research and Development. EPA-600/9-78-010. 121 pp.

American Society for Testing Materials. 1980. Standard Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates and Amphibians. E 729-80. Published by ASTM Committee on Standards, 1916 Race Street, Philadelphia, PA, 19103.

These referenced protocols are presented as flexible guidance to help researchers design scientific protocol and to help the reviewer validate studies. It is important to recognize that shrimp tests are validated based on whether they provide scientifically sound information on the acute toxicity of the test material to shrimp that is useful in risk assessments

and whether they fulfill guideline requirements. This is more important than whether they follow a referenced protocol step-by-step.

B. Test Organisms

1. Acceptable Species

The selected species should have a demonstrated sensitivity to known toxicants. If possible they should be species that occur in the area of exposure or that represent exposed species. In this case shrimp may represent many types of marine and estuarine invertebrate species.

Numerous species are specifically referenced in "Methods of Acute Toxicity Tests with Fish, Macroinvertebrates, and Amphibians" (Committee on Methods for Toxicity Tests with Aquatic Organisms, 1975, and ASTM E 729-80). The following species are preferred because there is a substantial data base available on them:

Penaeus setiferus	White shrimp
P. duorarun	Pink shrimp
P. aztecus	Brown shrimp
Palaemonetes sp.	Grass shrimp
Mysidopsis bahia	Mysid shrimp

Some other species may be acceptable if they have been shown to be sensitive in acute toxicity tests.

2. Size/Age/Physical Condition

Juvenile organisms should be used whenever possible. Shrimp bearing eggs should not be used. All organisms in a test should be approximately the same size and age.

Test organisms must be observed prior to testing for signs of disease, stress, physical damage, and mortality. Injured, dead, and abnormal individuals must be discarded. If the organisms show signs of disease or stress, remedial action must be taken during the acclimation period and not during the test phase. Organisms that have been treated for disease are acceptable for testing provided they do not exhibit signs of disease during the 48 hours pretest. Organisms must not be used if they appear to be diseased or stressed or if more than 3% die during the 48 hours immediately prior to testing.

3. Source/Acclimation

All organisms must be from the same source. This may include laboratory or commercial stocks. Organisms captured in the wild

are acceptable provided they meet the requirements pertaining to physical condition and age/size criteria mentioned above. Organisms captured via chemical treatment must not be used.

After collection, shrimp must be held for at least ten days for observation and acclimation. To avoid unnecessary stress, rapid changes in water temperature and quality must be avoided. Feeding, handling, and other maintenance must be such that the shrimp are not stressed, diseased, or damaged. All organisms must be maintained under actual test conditions (temperature and water quality) for at least 48 hours before the test actually begins.

Feeding of the organisms should be limited (without stressing the organism) just before and during testing. This reduces the amount of organic material generated in the test containers. Organic matter may alter the test results by either adsorbing the chemical or increasing the oxygen demand of the test solution. Young shrimp that have been actively feeding for less than 20 days must be fed up to the beginning of the test. If they are larger (over 0.5 grams each) they should be able to be held 24 hours before the beginning of the test without feed and not require feeding during the test. Experience and information from open literature will dictate the exact "time pretest without feed" necessary and appropriate; it may vary between species. This information must be provided in the report. If the test material tends to bind to organic material, shrimp species that can survive at least 48 hours without feed before testing should be used.

C. Test Solution

1. Source of Dilution Water

An adequate supply of dilution water that meets the minimum requirements mentioned below must be available. The water may be natural or reconstituted but must be able to support the test animals without stress. Natural water must be of constant quality as described below.

Natural or reconstituted seawater of 30 to 34‰ (ppt) salinity and pH of 8 to 8.3 should be used when testing marine (stenohaline) shrimp, and 10 to 17‰ salinity and pH 7.7 to 8.0 with estuarine (euryhaline) shrimp species. Natural seawater is considered to be of constant quality if the weekly range of salinity is less than 6‰, and if the monthly pH range is less than 0.8 of a pH unit. See the protocols by the American Society for Testing Materials (1980) or the Committee on Methods for Toxicity Tests with Aquatic Organisms (1975) for guidance on specific amounts of minerals in reconstituted seawater. Commercial sources of seawater mixture are acceptable provided they do not adversely affect the test organism or alter the toxicity of the test material.

2. Temperature

Most shrimp are to be tested at or around 22°C. The actual measured temperature should not deviate more than 1°C or so during the test. Wild captured shrimp should be held and tested within 5°C of the temperature of the water from which they were captured.

D. Testing System

1. Test Vessels

Test containers should be of welded stainless steel or glass. If other materials such as polyethylene are used, the toxicant concentrations must be measured. For static tests larger organisms (0.5 g each or more) should be exposed in 19.6 liter containers with 15 liters of solution. Smaller organisms may be exposed in 3.9 liter containers with two to three liters of solution. Flow-through containers may be slightly larger for each size category mentioned above.

2. Photoperiod

A 16-hour light and an 8-hour dark photoperiod should be provided, with a 15- to 30-minute transition period between light and dark. This schedule may be altered to match natural conditions if wild-captured shrimp are used.

3. Loading

The size of the test container should be such that the loading factor (test organism mass per volume of test solution) is no greater than 0.8 g/L test solution in static tests at or below 17°C or 0.5 g/L test solution at higher temperatures. For flow-through tests, the loading should be no greater than 1 g/L of solution passing through the chamber in 24 hours, and must not exceed 10 g/L at any time at or below 17°C or 5 g/L at higher temperatures.

4. Solvents

If solvents other than water are necessary, they should be used sparingly, not to exceed 0.5 ml/L in any test solution. The following solvents are preferred:

dimethyl formamide
triethylene glycol
methanol
acetone
ethanol

5. Flow-Through Tests

Flow-through tests are not usually required. They may be necessary if the test chemical is relatively insoluble, has a short half-life, or is volatile. The metering system chosen for a flow-through study must reproducibly supply appropriate toxicant concentrations at a consistent flow rate. Metering systems should be calibrated before and after each study and checked twice daily during the test period. Flow rates should be five to ten volume additions per 24 hours. Flow-through systems should be constructed so that the organisms are not stressed by turbulence. Concentrations must be measured in a flow-through system to verify the metering system.

E. Test Design

1. Test Levels (Nominal/Measured)

Initially, range finding tests may be necessary to define levels of the toxicant needed for definitive studies. Test reports should provide information describing range finding study procedures and results. The information should include sample sizes, test levels, and mortality data.

If it can be shown (by testing at least 30 individuals) that a chemical will have an LC_{50}/EC_{50} greater than 100 ppm, a definitive study need not be performed.

Definitive acute toxicity tests normally are designed to include one or more control groups and a geometric series of at least five toxicant levels to be tested. Each designated treatment group should be exposed to a concentration of toxicant that is at least 60% of the next highest concentration. If a formulated product is tested, it should be clearly stated in the test report whether results are expressed in terms of active ingredient alone or as total formulated product.

2. Number of Test Animals

No less than ten organisms per level in a static test and no less than 20 organisms per level in a flow-through design should be used. These may all be in one container or divided between two or more replicate containers. In every case, they must be randomly assigned to test containers.

3. Controls

Each test requires a concurrent control using the same dilution water and same number of organisms at each test concentration. If any solvent other than water is used a solvent control is also necessary. It should contain the highest concentration of the

solvent that was added to any of the test chambers. A test is not acceptable if more than 10% of the control organisms die during a static LC_{50} or 5% during a flow-through system.

4. Beginning the Test

Static acute tests are begun either by adding the test material to the test chambers after the organisms have been added or by adding the organisms to the test chambers within 30 minutes after the test material has been added to the dilution water.

5. Measurement of Diluent Characteristics

Temperature should be measured hourly throughout the acclimation and test periods in at least one test chamber if the test containers are not in a temperature controlled water bath because air temperature may change more frequently and to a greater extent than water, thus affecting the test container temperature. If the temperature is controlled by a water bath, the temperature of the bath may be recorded every six hours. Temperature should not vary more than one degree during the entire study period.

The dissolved oxygen (DO) concentration must be measured at the beginning of the test and every 48 hours thereafter to the end of the test in the control and the high, medium, and low concentration as long as shrimp are present at those concentrations. The DO level during the first 48 hours must be between 60% and 100% of saturation and between 40% and 100% saturation after 48 hours. In the flow-through test, the DO concentrations in each chamber must be between 60% and 100% saturation at all times during the study.

The pH should be measured at the beginning and end of the test in the control and the high, medium, and low toxicant concentrations.

6. Chemical Analysis

It may be preferred to chemically analyze test solutions to determine exact concentrations of pesticides. It is particularly important that residues are measured if:

- The test solutions were aerated;
- The test material was volatile, insoluble, or precipitated out of solution;
- The test containers were not made of glass or stainless steel;
- The test chemical is known to adsorb to the test containers structural material; or
- A flow-through system is used (measurement verifies accuracy of metering system).

III. REPORTING REQUIREMENTS

The test report submitted to the Agency must fully describe the materials and methods used to perform the study. The reviewer must be able to determine from the report that the study was performed under conditions that render the results acceptable for use in a risk assessment and/or for fulfilling a guideline requirement. The following information is particularly important for a complete evaluation.

A. Test Material

If the study is to be performed with the technical grade product, the test material should be clearly identified as to source, batch, and exact purity. Simply identifying the material as technical may not be sufficient because the percent active ingredient of some newer products may increase with time as the manufacturing process is improved to produce greater purity.

For studies involving the end-use product, the exact percent of the active ingredient and the type of formulation (e.g., granular, wettable powder) of the test material should be described. It should clearly state in the test report whether the results are expressed in terms of active ingredient or as formulation.

B. Dilution Water

Test reports submitted to the Agency should include a complete description of dilution waters used in the test. Descriptions should include identification of the source, the chemical characteristics of the water, and information on any pretreatment.

C. Holding of Test Organisms

Test reports should include complete information on holding and acclimation conditions including feeding schedules and treatment for diseases.

D. Mortality/Observable Effects

The criteria for determining effects must be defined. The raw data or percentage of deaths at each level as well as the number of organisms tested per level must be reported for each 24-hour period. Toxic symptoms (physical and behavioral) should be described.

E. Calculated LC50

The statistically calculated LC_{50} with 95% confidence limits and the method of calculation must be presented. In lieu of a calculated LC_{50}, the study may show that the LC_{50} is greater than 100 ppm. The

slope of the dose-response line should be calculated and reported. Some reports have a graphic (log probit/dose concentration) presentation which is helpful.

F. Temperature/DO/pH

Dissolved oxygen, pH measurements, and the range and average temperature during the study should be reported.

G. Chemical Analysis

If chemical analyses were conducted, the test report should provide information on the methods (references) utilized and the results of analyses. Residues found at the beginning and end of the study should be reported.

H. Testing Protocols

The test report should include reference to the testing protocol(s) used during the study.

IV. REVIEWER'S EVALUATION

A. Review of Test Conditions

The reviewer should identify each aspect of the reported procedure that is inconsistent with recommended protocol. The significance of these deviations must be determined. The number of deviations and their severity will determine the validity of the study and the interpretation of the results.

B. Verification of Statistical Analyses

The reviewer should ensure that the LC_{50} has been properly derived by recalculating these values. An acceptable acute toxicity test should provide not only an LC_{50} but also a NOEL (no observed effect level) and a slope of the dose/mortality response. These data can give further insight into the toxicological characteristics of the chemical such as whether the response is gradual, over a wide range, or rapid.

If the recalculated results differ substantially from the submitted results the reviewer should note this and attempt to explain the differences.

C. Conclusions

1. Categorization of Results

The significance of inconsistencies in the test procedures must be determined by the reviewer so that the results of the test can

be categorized as to whether they fulfill Part 158 regulations and are useful in performing a risk assessment. Categories are described as:

- Core: All essential information was reported and the study was performed according to recommended protocols. Minor inconsistencies with standard methodologies may be apparent; however, the deviations do not detract from the study's soundness or intent. Studies within this category fulfill the basic requirements of current guidelines and are acceptable for use in a risk assessment.

- Supplemental: Studies in this category are scientifically sound; however, they were performed under conditions that deviated substantially from recommended protocols. Results do not meet guideline requirements; however, the information may be useful in a risk assessment.

  Some of the conditions that may place a study in a supplemental category include:

  - Unacceptable test species;
  - Inappropriate test material;
  - Concentrations tested were less than 100 ppm but not high enough to produce an effect on the organisms or a precise LC_{50} or EC_{50}; and
  - Deviations from recommended test solution characteristics (variations in DO, temperature, hardness, and pH can affect toxicological response).

- Invalid: These studies provide no useful information. They may be scientifically unsound, or they were performed under conditions that deviated so significantly from recommended protocols that the results will not be useful in a risk assessment.

  Examples of studies placed in this category commonly include those where the test system was aerated, test vessels were constructed from materials other than glass, or there were problems of solubility or volatility of the test material. Unless acceptable chemical analyses of actual toxicant concentrations were performed in studies such as these, the reviewer cannot be sure that test organisms were actually exposed to nominally designated concentrations.

  A study where the test material was not properly identified can also be invalidated.

2. Rationale

Identify what makes the study supplemental or invalid. While all deviations from recommended protocol should be noted, the

reviewer is expected to exercise judgment in the area of study categorization.

3. Repairability

Indicate whether the study may be upgraded or given a higher validation category if certain conditions are met. Usually this would involve the registrant submitting more data on the study.

D. Descriptive Classification

The reviewer should indicate what the results were and how much information can be drawn from them. At a minimum, an acute toxicity test will provide an LC_{50} with 95% confidence limits. This should allow classifying the test material based on the following scheme:

LC_{50} (ppm)	Category Description
< 0.1	very highly toxic
0.1 - 1	highly toxic
1 - 10	moderately toxic
10 - 100	slightly toxic
> 100	practically non-toxic

These descriptive categories are for inter-chemical comparison only and do not reflect actual environmental risk to the test organism. The results may provide other useful information such as slope or a no observed effect level (NOEL). The NOEL is the highest test level in which no mortality or other toxic sign occurred. These additional data are useful in a risk assessment.

E. References

The reviewer should reference any information used in the validation procedure. This should include protocol documents, statistical methods, or information taken from files of other branches.